[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE COLLEGE OF LIBERAL ARTS OF NORTHWESTERN UNIVERSITY]

MERCURATED HYDROXYAZOBENZENES[1,2]

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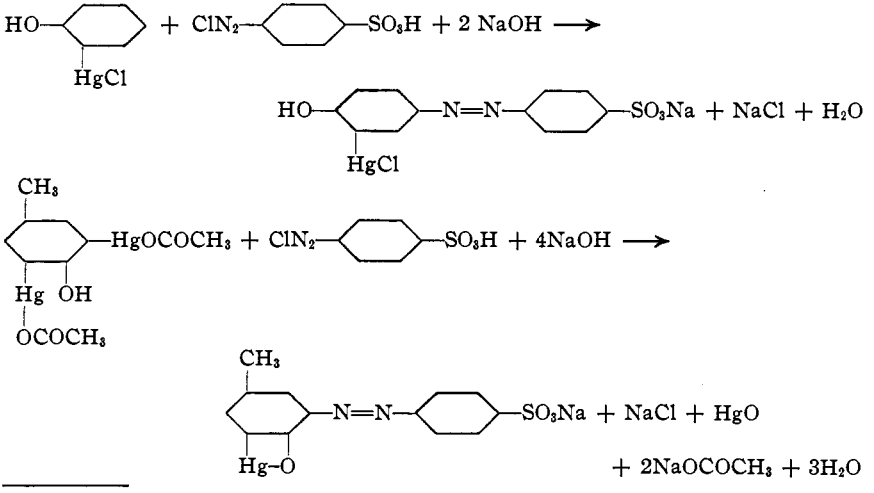
RECEIVED DECEMBER 7, 1925 PUBLISHED APRIL 5, 1926

Mercurated azo compounds have been prepared by the direct mercuration of azo dyes containing activating groups such as hydroxyl,[3] by the coupling of diazo solutions with mercurated phenols,[4] and by the coupling of diazotized mercurated amines with substances such as dimethylaniline.[5]

The present study was undertaken to obtain a series of related simple mercurated azo dyes containing solubilizing groups. Two mercury compounds were used, *o*-chloromercuriphenol[6] and 2,6-diacetoxymercuri-*p*-cresol.[7] These were coupled in alkaline solution with diazotized solutions of the following acids, sulfanilic, metanilic, naphthionic, anthranilic, *m*-aminobenzoic and *p*-aminobenzoic. The reactions involved are as follows.



[1] Presented at the 65th Meeting of the American Chemical Society, New Haven, April, 1923.

[2] This research was carried out under a grant from the Public Health Institute of Chicago. The substances obtained have been studied pharmacologically by A. S. Loevenhart under a similar grant at the University of Wisconsin.

[3] Smith and Mitchell, *J. Chem. Soc.*, **93**, 847–852 (1908); **95**, 1430 (1909). Proskouriakoff and Raiziss, THIS JOURNAL, **47**, 1974 (1925). Vecchiotti, *Gazz. chim. ital.*, **52** (I), 137 (1922); *C. A.*, **16**, 2126 (1922).

[4] Dimroth, *Chem. Zentr.*, **1901**, I, 452; *Ber.*, **35**, 2859–2864 (1902). Reitzenstein and Bönitsch, *J. prakt. Chem.*, [2] **86**, 80 (1912).

[5] Jacobs and Heidelberger, *J. Biol. Chem.*, **20**, 516 (1915); *C. A.*, **9**, 1610 (1915).

[6] Whitmore and Middleton, THIS JOURNAL, **43**, 622 (1921).

[7] Dimroth, *Ber.*, **35**, 2856 (1902).

It was hoped that the chemical activity of the mercury might be modified by the increase in the weight and the change in the nature of the molecule. This was not the case, however, as the mercury was removed by dilute acids and by aqueous iodide solutions as easily as from the mercurated phenol and cresol. There is little or no difference in the toxicities of the nine azo compounds that have been prepared pure enough for testing. Moreover, the toxicity is practically the same as that of the parent mercury compounds.[8]

Experimental Part

Sodium 3-Chloromercuri-4-hydroxy-azobenzene-4'-sulfonate

A solution of 14 g. of sulfanilic acid in 100 cc. of hot 1 *N* sodium hydroxide solution was diluted to 200 cc., cooled to 5°, and treated with 40 cc. of 1:1 hydrochloric acid. To this solution was added drop by drop, during mechanical stirring, a solution of 6 g. of sodium nitrite in 30 cc. of water until starch-potassium iodide paper showed an excess of nitrous acid after one minute. The diazo solution was added during stirring to a cold solution of 22 g. of *o*-chloromercuriphenol in 40 cc. of 2 *N* sodium hydroxide solution and 100 cc. of water. The addition required about one hour. In order to neutralize all of the acid, 50 cc. of 6 *N* sodium hydroxide solution was added during the same time. The coupling was complete in about four hours. The mixture was then acidified with acetic acid. The sodium salt of the azo compound separated as a heavy, orange-yellow precipitate. Evaporation of the mother liquor gave crystals of a deeper color. The product was recrystallized from hot water, air-dried and then dried in a vacuum dryer at 50°.

Anal. Subs., 0.3599, 0.3526: Hg, 0.1299, 0.1309. Calcd. for $C_{12}H_8O_4N_2ClSHgNa$: Hg, 37.5. Found: 36.1, 37.1.

Samples analyzing between these extremes were obtained. Attempts to prepare the free acid failed because of the ease with which the C—Hg linkage was split.

Similar products were obtained by coupling *o*-chloromercuriphenol with other diazotized aromatic acids as follows.

Amino acid	Product	Color	Formula	Anal., Hg, % Calcd.	Found
Metanilic	Na salt	yellow	$C_{12}H_8O_4N_2ClSHgNa$	37.5	37.1
Naphthionic	Na salt	orange	$C_{16}H_{10}O_4N_2ClSHgNa$	34.3	34.1
Anthranilic	Free acid	red	$C_{13}H_9O_3N_2ClHg$	42.1	40.0
m-Aminobenzoic	Free acid	red	$C_{13}H_9O_3N_2ClHg$	42.1	41.4
p-Aminobenzoic	Free acid	red-yellow	$C_{13}H_9O_3N_2ClHg$	42.1	41.6

Sodium Anhydro-2-hydroxy-3-hydroxymercuri-5-methyl-azobenzene-4'-sulfonate

To a solution of 9.6 g. of sulfanilic acid in 200 cc. of water and 10 cc. of hydrochloric acid, cooled to 5°, a concentrated sodium nitrite solution was added drop by drop during mechanical stirring, until the excess of nitrous acid persisted for one minute. A solution of 31.2 g. of 2,6-diacetoxymercuri-*p*-cresol in 200 cc. of 3 *N* aqueous sodium hydroxide, cooled to 5°, was added to the diazo solution during stirring. The mixture turned red and mercuric oxide precipitated. The stirring was continued for ten hours

[8] Private communication, A. S. Loevenhart, Department of Pharmacology, University of Wisconsin.

during external cooling with ice. After filtration, the solution was acidified with acetic acid. The slightly soluble, yellow sodium salt precipitated. It was purified by recrystallization from water.

Anal. Subs., 0.2993, 0.2983, 0.2318: Hg, 0.1153, 0.1138, 0.0868. Calcd. for $C_{13}H_9O_4N_2SHgNa$: Hg, 39.1. Found: 38.5, 38.2, 37.5.

Attempts to prepare the free acid were unsuccessful. The action of strong acids removed the mercury completely. The presence of the anhydro structure due to loss of water between the adjacent hydroxy and hydroxymercuri groups was proved by the absence of acetate and chloride groups in the substance. Attempts to prepare the chloride from the anhydro compound were unsuccessful. The methods used were coupling in a saturated sodium chloride solution, evaporation of an alkaline solution of the anhydro compound with a large excess of sodium chloride, and by adding the anhydro compound to an excess of sodium chloride solution containing half the amount of base equivalent to the anhydro compound, filtering and acidifying with acetic acid. In every case the product was free from chloride and acetate.

Anhydro-2-hydroxy-3-hydroxymercuri-5-methyl-azobenzene-2'-carboxylic Acid

This substance was prepared from anthranilic acid in much the same way as the sulfanilic acid derivative except that the coupled solution was diluted to 4 liters and filtered to remove a small amount of insoluble material before being acidified. The free acid is deep red. No method for purifying the acid was found because of its insolubility in all except basic solvents. A fairly pure product was obtained directly, however, by using exact quantities of carefully purified anthranilic acid and mercurated cresol.

Anal. Subs., 0.3103, 0.2124, 0.2155: Hg, 0.1352, 0.0929, 0.0935. Calcd. for $C_{14}H_{10}O_3N_2Hg$: Hg, 44.1. Found: 43.6, 43.7, 43.4.

Anhydro-2-hydroxy-3-hydroxymercuri-5-methyl-azobenzene-4'-carboxylic Acid

The preparation and properties of this substance were much like those of its isomer.

Anal. Subs., 0.2059, 0.2188: Hg, 0.0892, 0.0960. Calcd. for $C_{14}H_{10}O_3N_2Hg$: Hg, 44.1. Found: 43.3, 43.9.

The coupling of diazotized solutions of metanilic, *m*-aminobenzoic and naphthionic acids with the dimercurated cresol was carried out but no conditions were found under which definite compounds were obtained.

All of the mercury compounds described in this paper reacted with hot 1 *N* hydrochloric acid and with hot aqueous sodium iodide, with the complete splitting of the carbon-mercury linkages. No difference in the stability of this linkage in the different compounds was detected.

Summary

1. A series of simple mercurated azo dyes containing solubilizing groups has been prepared from *o*-chloromercuriphenol and 2,6-diacetoxymercuri-*p*-cresol with diazotized solutions of the following acids: sulfanilic, metanilic naphthionic, anthranilic, *m*-aminobenzoic and *p*-aminobenzoic.

2. The stability of the C—Hg linkage is found to remain essentially the same as in the parent compounds.

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THE IRREVERSIBLE REDUCTION OF ORGANIC COMPOUNDS II. THE DIMOLECULAR REDUCTION OF CARBONYL COMPOUNDS BY VANADOUS AND CHROMOUS SALTS

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RECEIVED DECEMBER 22, 1925 PUBLISHED APRIL 5, 1926

Several investigations have been carried out in this Laboratory in the past few years in order to discover to what extent it is possible to formulate the reduction of organic substances in electrochemical terms.[1] Attention has been centered on homogeneous systems in order to avoid the complications of diffusion processes and, therefore, such soluble reducing agents as stannous, titanous, vanadous and chromous salts have been employed. The irreversible reduction of most azo and nitro compounds, unsaturated 1,4-diketones (and related compounds) and 1,2-diketones can be readily accomplished by titanous chloride or some reducing agent of even higher potential (for example, stannous chloride).[2] Since chromous chloride is the most powerful soluble reducing agent known (π_0 = —0.4 volt), we have been interested in determining its action on various classes of organic compounds which are not reduced by the more usual soluble reducing agents.

Berthelot[3] discovered that acetylene was reduced to ethylene by ammoniacal chromous chloride. Traube and Passarge[4] showed that the same process occurred in acid solution and that fumaric and maleic acids were reduced by chromous chloride.[5]

[1] (a) THIS JOURNAL, **44**, 1382, (b) 2480 (1922); (c) **45**, 1047, (d) 2194 (1923); (e) **46**, 1254, (f) 1858 (1924); (g) *J. Phys. Chem.*, **28**, 1096 (1924).

[2] For the quantitative formulation of such processes see THIS JOURNAL, **46**, 1254 (1924) and **45**, 1048 (1923).

[3] Berthelot, *Ann. chim.*, [4] **9**, 401 (1866).

[4] Traube and Passarge, *Ber.*, **49**, 1692 (1916).

[5] These authors also carried out experiments with alkaline suspensions of chromous hydroxide. Since one must here consider the possibility of reduction on an active surface, experiments with this reagent do not lend themselves to precise electrochemical treatment.